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COMBUSTIBLE AMMUNITION FOR SMALL ARMS

I. DEVELOPMENT OF SELF-CONTAINED PROPELLANT CHARGE

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OCO Project TS1-2

DA Project 504-05-002

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FRANKFORD ARSENAL

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LABORATORIES GROUP

PHILADELPHIA 37, PA

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OBJECT

To conduct a feasibility study of small caliber combustible ammunition, using the 7.62 mm cartridge as the test vehicle

SUMMARY

A molded, integral propellant charge has been developed which, when used in conjunction with a metal case stub in a modified 7.62 mm test action, yielded performance meeting the ballistic requirements for the M59 cartridge.

The molded charge consisted of IMR 4895 granular propellant molded in a configuration similar to the 7.62 mm brass case, using nitrocellulose (pyroxylin) dissolved in ether-alcohol as the binder.

The results indicate the feasibility of small caliber combustible ammunition. Work is in progress to develop a fully combustible round, complete with consumable primer and protective coating.

AUTHORIZATION

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COMBUSTIBLE AMMUNITION FOR SMALL ARMS
I. DEVELOPMENT OF SELF-CONTAINED PROPELLANT CHARGE

INTRODUCTION

Among the advantages offered by the elimination of the conventional metal cartridge case in small arms are:

1. Reduction in weight of the complete round;

2. Elimination of the need for extraction (and, in the case of tank or aircraft, storage space for spent ammunition);

3. Higher cyclic rates of fire; and

4. Elimination of the need for the expensive, and perhaps critical, brass cartridge case.

Considerably greater effort has been directed toward the development of a combustible cartridge case for artillery and recoilless rifle ammunition than toward development of a combustible cartridge for small arms. Under the latter, a combustible cartridge case based upon an oxidizer-impregnated gauze was developed as part of a program involving development of an aircraft gun. However, machine gun tests with rounds containing this case formulation revealed that characteristics inherent in this oxidizer preclude its use as a constituent of combustible cases for small arms ammunition (1)*.

Research on development of combustible cartridge cases for small arms was conducted in Germany during World War II. Subsequent to the end of the war, work on combustible cased ammunition for small arms was conducted in Spain by the Belgian firm of SIDEM International under contract to the European Office of the U. S. Air Force Research and Development Command (2). Both 7.92 mm and 20 mm combustible ammunition, capable of being fired single shot in modified test actions, were developed under this effort. The 7.92 mm combustible cartridge consisted essentially of a molded case with ribbed inner walls composed of ball propellant and a mixed cellulose ester (of acetic and butyric acids) binder. The 20 mm cartridge case was similar except that the

*See attached Bibliography.

inner wall of the case was smooth. These cases were loaded with the amount and type of loose granular propellant required to meet the desired ballistic performance. The primers used in these cartridges were also combustible. Since elimination of the metal cartridge case introduces the problem of obturation (sealing the chamber against loss of combustion gas), conventional small arms test actions were modified to obtain satisfactory obturation with the combustible rounds. Tests were conducted in the United States with both the 7.92 mm and 20 mm combustible cartridges. The 7.92 mm round yielded low mean velocity (with individual shots exhibiting considerable velocity dispersion) as well as poor accuracy. In addition, the cartridge cases were not completely consumed, with propellant residue found in the test action after firing. The poor accuracy was attributed by SIDEM to notches cut into the bullet to secure proper adhesion between the projectile and the combustible cartridge case (3). The 20 mm combustible round (designed to be fired from a modified M24 test action and to duplicate the performance of the 20 mm M99 metal-cased round) was found to be generally unsatisfactory (4). At 70° F, the mean velocity obtained with the combustible round was approximately 120 ft/sec lower than that yielded by the standard M99 round. At temperatures other than 70° F (viz., 130°, 0°, -30°, and -65° F), 58 percent of the combustible rounds misfired. A considerable portion of the case was found to be unconsumed during the ballistic cycle. In addition, the combustible case was found to be very fragile, one round shattering after being dropped from a height of 30 inches. This development has since been terminated by the U. S. Air Force.

APPROACH

The work described here is a feasibility study of small caliber combustible ammunition capable of exhibiting satisfactory ballistic, chemical, and physical properties, such as:

1. Complete consumption during ballistic cycle with no corrosive combustion products.

2. Ability to withstand the high temperatures developed in the chamber of an automatic weapon. These temperatures should be higher than those obtained in a gun firing metal cased ammunition, since the metal case acts as a heat sink (by ejection of the hot, spent case), thus reducing the quantity of heat transferred to the chamber and barrel. In addition, the metal case acts as a barrier between the heated chamber wall and the propellant.

3. Ability to withstand immersion in water and environmental conditions such as high humidity.

4. Ability to withstand, over the required temperature range, the forces to which it would be subjected in an automatic weapon as well as to withstand normal handling and shipping.

Since 7.62 mm ammunition and weapons have recently been standardized, it was decided to use this caliber as the initial test vehicle and attempt to develop a combustible cartridge meeting ballistic specifications for this round (with the M59 ball projectile). As mentioned previously, a development of this type inherently includes modification of the conventional 7.62 mm test action or gun to permit satisfactory functioning with combustible ammunition. While the requirement of a combustible primer or, more generally, a means of ignition which leaves no significant residue in the gun or test action, is also inherent in this program, it was decided to direct effort initially toward establishment of a self-contained propellant charge, using the stub of a 7.62 mm metal case for ignition. Once the self-contained propellant charge, which exhibited desired performance characteristics, was established, the development of a percussion sensitive combustible primer was to be undertaken.

Initially, several different approaches to the development of a propellant charge for small arms combustible ammunition were considered. It was required that the propellant charge be completely consumed in the ballistic cycle, have a high loading density, and yield gases which would not cause corrosion of the gun or produce excessive smoke. Among the approaches considered were:

1. Slotted tubular propellant held together as an integral charge by a suitable binder. Rate of gas evolution would be controlled by variation in composition and web of the tubular propellant as well as the nature of the binder. This concept was not pursued since the desired case configuration could be more easily attained by using a suitable binder in conjunction with small granular propellant than with long rods of tubular propellant. In addition, application of a satisfactory deterrent coating to the long rods of slotted tubular propellant (so as to obtain burning rate progressivity) posed a severe problem.

2. Large, single pieces of multiperforated propellant grain. Burning rate would be controlled by variation in the composition and geometry of the grain. While a grain of this type should offer considerable physical strength, it was not believed that this approach would yield both the high rate of gas evolution and high loading density required for small arms application.

3. Relatively large grain extruded in a shape presenting considerable surface area. The objection to such a system lies in the low loading density which would be obtained with a charge of this type.

Two general lines of approach were finally selected in regard to the development of a self-contained propellant charge for combustible 7.62 mm ammunition. These are:

1. Caseless Ammunition - Wherein the propellant charge (which would duplicate the configuration of the 7.62 mm case) is an integral unit, i.e., no loose granular propellant is required to attain the desired ballistics. An example of this approach would be the use of small granular extruded or ball propellant held together as an integral charge by a suitable binder and bonded to the base of the bullet. Burning rate could be controlled by the type of granular propellant as well as the nature of the binder.

2. Combustible Cased Ammunition - Wherein a combustible case replaces the conventional metal case, the case being loaded with the charge and type of loose granular propellant required to meet the desired ballistic performance. Examples of this approach are.

a. Combustible case composed of high energy oxidizer-fuel composition.

b. Combustible case composed of small granular extruded or ball propellant held together by a suitable binder.

Except where noted, peak pressures were obtained with a piezoelectric gage. Propellant ignition times and barrel times were read from the pressure-time trace. All firings were conducted at 70° F, using the M59 ball bullet with both experimental and standard rounds. Specification requirements call for a velocity of 2750 ± 30 ft/sec at 78 feet, at a maximum mean pressure of 50,000 psi (copper), with a maximum barrel time of four milliseconds.

RESULTS

Caseless Ammunition

Preliminary tests were conducted using hollow molded cylinders of IMR 4895 and IMR 4475 extruded propellants prepared with an

acetone binder. These cylinders, 1.25 inches in length, were inserted in a 7.62 mm brass case (No. 34 primer) which was cut in two, 0.50 inch from the base. The outer diameter of the molded cylinders was held to 0.375 inch to permit insertion into the split case. Subsequent to failure of the first round, the inner diameter of the molded cylinders was enlarged from 0.125 to 0.188 inch to permit addition of a relatively fast burning, loose granular propellant, SR 4759, to improve ignition. The dimensions of the propellants used in this series, as well as in subsequent tests, are presented in Table I. With the exception of the IMR 4227 base grain, which is uncoated, all are extruded, single base propellants with a dinitrotoluene coating.

Table I. DIMENSIONS OF PROPELLANTS

	Length (in.)	Diameter (in.)	Perforation (in.)	Web (in.)
IMR 4475	0.042	0.031	0.007	0.012
IMR 4895	0.058	0.033	0.007	0.013
SR 4759	0.058	0.047	0.018	0.015
IMR 4227 base grain	0.023	0.025	0.006	0.010

Firings were conducted in a 7.62 mm test barrel which was modified by machining two grooves into the wall near the rear of the chamber and placing neoprene "O" rings in these grooves. The inner diameter of the rings was such that they fitted tightly around the rear section of the brass case, thus reducing gas leakage which might be due to use of the split metal case. These rings were replaced after each firing. To hold the case stub firmly in place and to reduce further the gas leakage, a steel collar (0.051 inch thick) was made in the form shown in Figure 1. The collar fitted tightly around the extraction groove of the metal stub, which extends from the rear of the 7.62 mm test barrel, while the circular outer form permitted the collar to fit tightly into the annular section on the rear face of the test barrel.

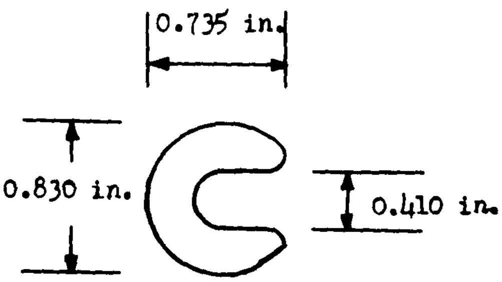

Figure 1. Collar

The results of firing tests with the molded cylinders are presented in Table II.

The velocities and pressures were extremely low; reproducibility was poor; and incomplete burning was obtained in all rounds fired. This indicated that the acetone binder had too great a solvent action, causing the grains to lose their individuality and resulting in a charge whose burning rate was not a function of the constituent grains.

Effort was then directed toward use of a more suitable binder which would yield molded charges having satisfactory physical strength and be completely consumed in the test action. A solution of 3 percent, by weight, nitrocellulose (pyroxylin) in a 1:1 ether-alcohol mixture was found to produce molded samples of high physical strength which could be easily machined. The appearance of the molded samples (one in which the constituent grains appeared to retain their individuality) suggested that satisfactory ignition might be effected without use of loose, granular propellant as a booster charge. Therefore, it was decided to eliminate the booster charge and prepare an integral grain, duplicating the configuration of the brass case. These charges were prepared in the following manner.

Table II. PERFORMANCE OF MOLDED CHARGES (ACETONE BINDER) IN SPLIT 7.62 MM CASES

Molded Charge		Loose Propellant		Piezoelectric Pressure (psi)	Velocity at 78 ft (ft/sec)	Barrel Time (msec)	Remarks
Type	Wt (gr)	Type	Wt (gr)				
IMR 4475	40.2	-	-	-	-	-	Bullet lodged in barrel
IMR 4895	31.9	SR 4759	5.9	10,700	853	-	Considerable residue
IMR 4475	32.7	SR 4759	5.2	17,000	1234	2.05	Slight residue
IMR 4475	32.6	SR 4759	5.2	26,800	1476	1.70	Very little residue
IMR 4475	35.3	SR 4759	4.9	15,500	1051	2.20	Considerable residue

An unprimed brass stub was inserted in the bottom of a 7.62 mm heading die and approximately 0.2 ml of the binder was placed within it. Approximately 4 grains of the given granular propellant were added, followed by three drops of binder. This process was continued until the desired height was reached. At this time the material was compressed at 300 psi for 30 seconds, permitting the excess binder to be expelled. After examination of the neck region for consolidation, the material was pressed out at minimum pressure and dried for 24 hours at room temperature. The resulting product was a hard, cylindrical rod with flat ends. This was then machined to duplicate the configuration of the standard 7.62 mm brass case. The cylinders were easily machined without danger of cracking or deformation. To permit insertion of the bullet, a pocket was provided in the necked-down portion of the charge to accommodate an M59 ball bullet, to which it was bonded. In addition, a perforation was drilled along the longitudinal axis of the molded charge to effect rapid ignition down the length of the propellant bed as well as to control charge weight. The outer diameter of the rear of the charge was reduced slightly to accommodate a brass stub (0.50 inch long) which was used for ignition and obturation. The stub (Figure 2) was slightly tapered on the outer surface to aid in obturation as well as to permit easy insertion past the "O" rings in the chamber.

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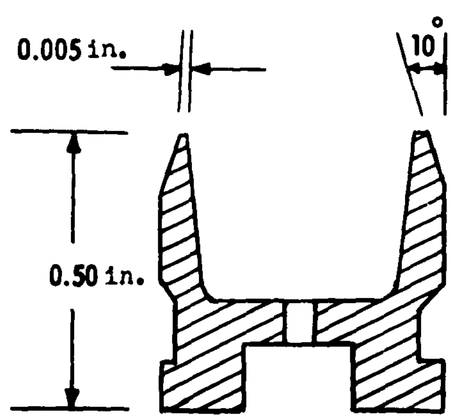


Figure 2. Stub

Molded charges were prepared, using four extruded propellants of varying relative quickness as the granular constituents. Slightly lower charge weights were used in those rounds containing the two propellants of highest relative quickness. The results are presented in Table III. All of the rounds were completely consumed, leaving no residue in either the chamber or barrel. Paper screens placed approximately five feet from the muzzle revealed no unburned propellant ejected from the muzzle.

Table III. EFFECT OF RELATIVE QUICKNESS OF GRANULAR PROPELLANT UPON PERFORMANCE OF MOLDED CHARGES (PYROXYLIN BINDER) WITH METAL STUB

Molded Charge	Relative Quickness[a]	Weight (gr)	Piezo-electric Pressure (psi)	Velocity at 78 ft (ft/sec)	Propellant Ignition Time (msec)	Barrel Time (msec)
IMR 4895	115	53	48,400	-	0.35	1.65
IMR 4895		53	44,800	2588	1.10	2.40
IMR 4475	130	54	48,400	2710	1.30	2.50
IMR 4475		56	66,600	2927	0.75	1.80
SR 4759	210	49	52,800	-	0.80	2.15
SR 4759		51	49,800	2521	0.65	1.85
IMR 4227 base grain	approx 235	45	67,800	2765	1.30	2.35
IMR 4227 base grain		49	77,400	2741	0.85	1.90

[a]Relative quickness values based on value of 100 assigned to IMR 4350

It is seen that, in general, the ballistics varied with the relative quickness of the constituent propellant grains; thus, the rate of consumption of the molded charges was a function of the individual propellant grain. The molded charges, consisting of IMR 4895 and IMR 4475, yielded

performance nearest to specifications for the standard round. Barrel times with all the molded charges were within the maximum limit of four milliseconds. The considerable difference in performance of the two IMR 4475 rounds (with a weight difference of only two grains) suggests that there may be a reproducibility problem with this type. On the other hand, the pressures obtained with the two IMR 4895 rounds (equal charge weight) are in good agreement.

In view of the above results, it was decided to evaluate further both the IMR 4895 and IMR 4475 propellants as constituents of the molded charges. Additional rounds were prepared containing various charge weights of the two propellants. As in the previous series, the rear of the molded samples was turned down to accommodate an 0.50-inch stub of the brass case. The results of these firings are presented in Table IV.

Table IV. EFFECT OF CHARGE WEIGHT OF IMR 4895 AND IMR 4475 UPON PERFORMANCE OF MOLDED CHARGES WITH METAL STUB

Charge Weight (gr)	Piezoelectric Pressure (psi)	Velocity at 78 ft (ft/sec)	Propellant Ignition Time (msec)	Barrel Time (msec)
		IMR 4895		
49.0	38,700	2381	1.40	2.85
49.0[a]	30,600	2243	2.00	3.55
50.5	43,000	2500	1.30	-
50.5	45,000	2647	1.75	3.10
53.0[a]	42,200	2494	-	-
53.0	47,200	2609	1.30	2.70
55.0	43,700	2743	0.60	1.80
55.0	37,300	2541	0.55	2.05
		IMR 4475		
49.0	45,200	2571	1.40	2.70
50.0	40,800	-	0.20	-
52.0	69,500	2948	0.60	1.80
52.0	54,200	2878	1.50	2.65
53.0	48,400	2703	0.30	1.65
53.0	54,600	2824	0.50	1.80
55.0	63,100	2971	0.50	1.65
55.0	50,400	-	0.40	1.65

[a]Considerable gas leakage through breech

All of the test rounds were completely consumed, leaving no residue in either the chamber or barrel. Paper screens mounted five feet from the muzzle revealed no unburned propellant ejected from the muzzle.

Following are some comments regarding these results.

1. Velocity - It appears that IMR 4895 velocities increase with charge weight; however, there is variation with identical charges. With IMR 4475, no relationship between velocity and charge weight is evident, indicating poor reproducibility. Some of the individual velocities were extremely high.

2. Pressure - With IMR 4895, no general relationship between pressure and charge weight was evident. However, none of the pressures (piezoelectric) exceeded the maximum pressure specification of 50,000 psi (copper). The relationship between piezoelectric and copper pressure readings is discussed in a subsequent section in this report. With IMR 4475, there was also no evident relationship between pressure and charge weight. Several extremely high pressures were obtained even though duplicate rounds of corresponding charge yielded pressures 15,000 psi lower, again indicating considerable variation with this propellant.

3. Propellant Ignition Time - With both IMR 4895 and IMR 4475, an increase in charge weight resulted in a corresponding decrease in propellant ignition time. This is probably attributable to the fact that the charge weight is controlled by the diameter of the longitudinal perforation. Thus, the primer blast would be less dissipated in a smaller perforation (greater charge weight), resulting in more rapid fragmentation and consumption of the molded charge.

4. Barrel Time - As would be expected on the basis of the above, this parameter decreases with an increase in charge weight of both propellants. All barrel times are within the specification limit of four milliseconds.

Thus, even though IMR 4475 appears to offer a higher potential than IMR 4895, reproducibility is more of a problem with the former. It was therefore decided to discontinue work on IMR 4475 and continue with IMR 4895. It should be noted that the term "ballistic reproducibility," as used herein, represents a combination of two effects, variation in the rate of fragmentation and consumption of the combustible cartridge (i.e., irreproducibility inherent in the molded charge due to such factors as the surface of the drilled perforations, amount of binder, etc.), and variation in the degree of gas leakage through the breech of the test action.

Firings were then conducted, using IMR 4895, AL 41024, in conjunction with the 0.50-inch brass case stub. For comparison, standard M59 rounds (loaded with WC 846 ball propellant) were fired, with pressures determined by both copper crusher and piezoelectric gages. The results are presented in Table V.

All of the test rounds were completely consumed, leaving no residue in either the chamber or barrel. Paper screens mounted fifteen feet from the muzzle revealed no unburned propellant ejected from the muzzle. No breech flaming was observed in any of the firings.

The following comments may be made regarding the above results.

1. Ballistic reproducibility of the molded charges was poorer than that of the standard M59 cartridge. As stated previously, this is probably due to a combined combustible cartridge-test action reproducibility problem.

2. With the standard M59 cartridge, the ratio of the mean pressure determined with the piezoelectric and copper crusher gages was 54,200/49,800, or 1.09. Assuming that the same ratio holds for the molded charges, the mean pressure obtained with the 57.0-grain charge is well within the specification limit of 50,000 psi maximum mean pressure (copper).

3. While the mean velocity of the 57.0-grain molded charge was 147 ft/sec less than that of the standard M59 cartridge (piezoelectric gage conditions), the mean pressure of the molded charge was also considerably lower (40,600 psi as compared with 54,200 psi for the standard round). Barrel times with the molded charge were slightly higher than those with the standard round. However, all were well within the specification limit of four milliseconds. Propellant ignition times were also slightly higher due to the time required to shatter the molded charge.

On the basis of the velocity-pressure ratio it appeared that a slight increase in charge weight, coupled with improved obturation with the metal stubs, might result in a molded charge equalling the performance of the standard round. To further improve obturation (and reduce ballistic variation), the collar used in the annular section at the rear of the chamber was removed and the rear of the test action was built up by a steel washer which fitted tightly into the annular section. Neoprene washers (replaced regularly) were placed between the rear face and the steel washer. Thus, the rear of the test barrel was a flat surface providing support for the complete metal case stub and continuous contact

Table V. COMPARISON OF PERFORMANCE OF MOLDED CHARGES OF IMR 4895 WITH METAL STUB AND STANDARD AMMUNITION

Charge	Pressure (psi) Piezo-electric	Pressure (psi) Copper Crusher Gage	Velocity at 78 ft (ft/sec)	Propellant Ignition Time (msec)	Barrel Time (msec)
55.0 gr IMR 4895					
	41,200		2361	1.55	*
	31,800		2348	0.55	1.90
	28,500		2300	0.45	1.90
	41,500		2531	0.55	1.85
Avg	35,800		2385	0.78	1.88
Ext Var	13,300		231	1.10	0.55
57.0 gr IMR 4895	35,900		2528	0.25	1.55
	46,400		2710	1.00	2.20
	45,500		2826	0.20	1.30
	34,600		2518	0.40	1.75
	40,800		2597	0.55	1.80
Avg	40,600		2636	0.48	1.72
Ext Var	11,800		308	0.45	0.90
Standard Cartridge					
	53,900		2785	0.20	1.40
	55,300		2769	0.20	1.25
	52,600		2786	0.15	1.30
	54,200		2779	0.20	1.30
	55,200		2794	0.20	1.20
Avg	54,200		2783	0.19	1.29
Ext Var	2,700		25	0.05	0.20
		48,700	2744	-	-
		50,700	2765	-	-
		49,500	2752	-	-
		48,500	2733	-	-
		51,600	2734	-	-
Avg		49,800	2746		
Ext Var		3,100	32		

*Missed; too long to be recorded on pressure-time trace

between the rear of the chamber (loaded with a case stub) and the firing pin assembly. Using this system, firings were conducted with IMR 4895 molded charges of 57.0 and 59.0 grains. The results are presented in Table VI.

Table VI. PERFORMANCE WITH MOLDED CHARGES OF IMR 4895 WITH METAL STUB USING IMPROVED OBTURATION

Charge Weight (gr)	Piezoelectric Pressure (psi)	Velocity at 78 ft (ft/sec)	Propellant Ignition Time (msec)	Barrel Time (msec)
57.0	39,700[a]	2507	0.25	1.55
	45,300	2686	0.30	1.60
	-	2709	-	-
	47,000	2674	0.30	1.50
Avg	44,000	2644	0.28	1.55
Ext Var	7,300	202	0.05	0.10
59.0	48,400	2763	0.25	1.50
	52,000	2717	1.00	2.25
	-	2784	-	-
	39,500[b,c]	2699	-	-
	48,400	2731	0.30	1.50
Avg	49,600	2739	0.52	1.75
Ext Var	3,600	85	0.75	0.75
Ballistic specifications	50,000[b]	2750 ± 30		4.00

[a]Gas leakage

[b]Copper

[c]Not included in average since pressure was measured by copper crusher gage, which yields lower values than the piezoelectric gage.

As before, all the test rounds were completely consumed, leaving no residue in the chamber or barrel. No breech flaming was observed. Very little or no carbon deposit was found on the metal stubs with the

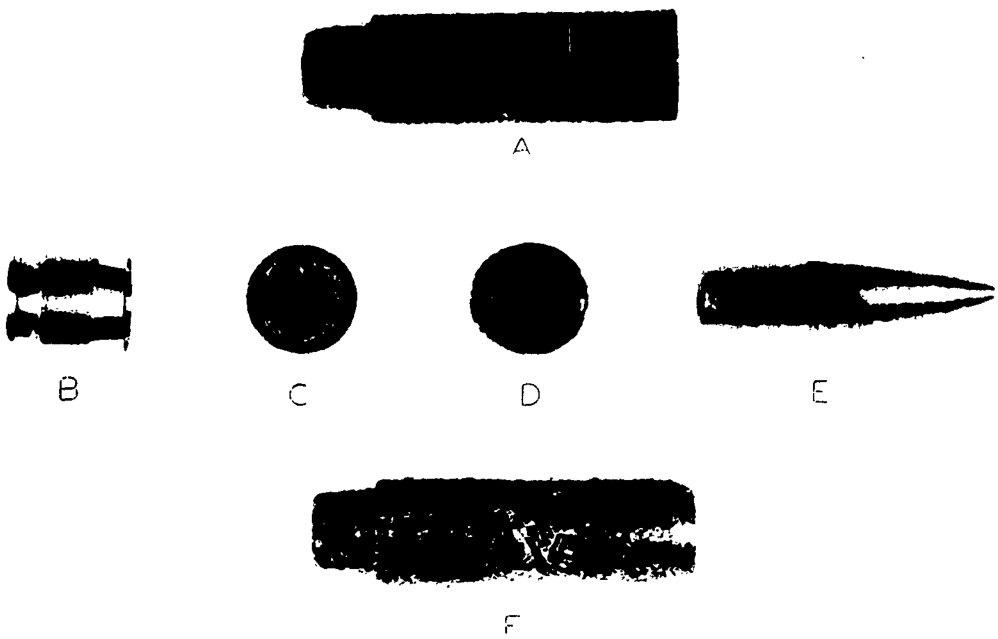
exception of the first round in the 57.0-grain series which gave low velocity. Paper screens mounted fifteen feet from the muzzle revealed no unburned propellant ejected from the muzzle. No substantial difference was observed between muzzle flash emitted by the molded charges and that emitted by standard ammunition.

With the exception of the propellant ignition time, the shapes of the pressure-time traces yielded by the 59.0-grain molded charges and the standard M59 rounds were practically identical. Pressure at muzzle exit was approximately 10,000 psi with both the molded and metal cased rounds.

The mean velocity and action time meet specification requirements for the M59 round. As previously described, firings with the standard round indicated the ratio of pressures measured by piezoelectric to those by copper crusher gages was 1.09. Since specifications call for a maximum mean pressure of 50,000 psi (copper), the corresponding piezoelectric pressure would be 54,500 psi. Therefore, the mean pressure of 49,600 psi (piezoelectric) obtained with the 59.0-grain molded charge was well within specification limits. This is also indicated by the pressure of 39,500 psi (copper) obtained with one round in the series.

Thus, the 59.0-grain IMR 4895 molded charge, when used in conjunction with a metal case stub in a modified Universal test action, yielded performance meeting the specifications for the 7.62 mm M59 cartridge. The experimental round and the molded charge alone are illustrated in Figure 3.

The meeting of ballistic specifications with the above molded charges must, of course, be regarded as an interim development since a metal case stub was used as part of the round. However, it does indicate the feasibility of meeting 7.62 mm ballistic requirements with caseless ammunition composed of a molded, integral charge (i.e., not containing any loose granular propellant). It is in the use of the molded, integral propellant charge that this development is unique. While SIDEM International developed a combustible cartridge for a similar caliber (7.92 mm), their cartridge consisted of a molded combustible case which contained loose granular propellant to achieve the desired ballistics. An integral molded charge, such as that described in this report, should exhibit better physical strength than the molded combustible cased round since the former will naturally have a thicker case wall.



A - Molded Charge
B - Brass Stub
C - Molded Charge (rear view)
D - Molded Charge (bullet pocket)
E - M59 Ball Bullet
F - Molded Charge (final form)

Unassembled View

Assembled View

Figure 3. IMR 4895 Molded Charge with Metal Stub

Combustible Cased Ammunition

Concurrent with the above caseless development, limited studies were conducted to determine the feasibility of 7.62 mm combustible cased ammunition. Initial tests were conducted, using an essentially nonporous combustible case of a high energy polymer composition (polypetrin acrylate with additives) developed at this arsenal under another project (5). This case, which had a wall thickness of approximately 0.06 inch and whose outer configuration was similar to that of the standard 7.62 mm brass case, was produced by casting in a mold. A pocket was provided in the necked-down portion of the case to accommodate an M59 bullet. The rear of the case was turned down to take an 0.50 inch brass case stub (for ignition and obturation). A typical combustible cased round (without metal stub) is illustrated in Figure 4. Exploratory firings were conducted with this combustible case into which was loaded various charge weights of loose granular IMR 4475 propellant. These firings were conducted in the test barrel which had the rear face built up to improve obturation. The results of these firings are presented in Table VII.

Table VII. PRELIMINARY FIRINGS WITH HIGH ENERGY POLYMER COMBUSTIBLE CASE

Case Weight (gr)	IMR 4475 Propellant Weight (gr)	Piezoelectric Pressure (psi)	Velocity at 78 ft (ft/sec)	Propellant Ignition Time (msec)	Barrel Time (msec)
37.2	15.0	--	2088	0.20	-
35.7	20.0	35,600	2175	0.50	2.10
38.6	22.9	71,400	2706	0.40	1.60

In all three firings, sparklers or streamers of white smoke were emitted from the muzzle for approximately one half to a full second after firing. Each round produced a considerable number of holes in a paper screen fifteen feet from the muzzle as well as leaving residue in the chamber. These observations all indicated incomplete consumption of the high-energy polymer case during the rapid ballistic cycle of the 7.62 mm. In view of this and the relatively poor velocity/pressure ratios obtained with these combustible cased rounds, it was decided to terminate work with this particular formulation and investigate the feasibility of different combustible case materials for use in the 7.62 mm cartridge.

Figure 4. Combustible Cased Round

CURRENT AND FUTURE DEVELOPMENT PROGRAM

Studies to date have indicated the feasibility of developing a molded, integral charge (i.e., no loose propellant) which will yield ballistics similar to those of the standard 7.62 mm cartridge. These charges were used with a metal case stub which provided ignition and partial obturation. Increased obturation was obtained by modification of the conventional Universal 7.62 mm test action. This type of action, however, is not suitable for combustible ammunition. Consequently, a 7.62 mm test action intended for use with combustible ammunition has been designed and fabricated. This test action, which is based upon the Springfield type receiver, provides obturation in the breech. It is currently being used in studies involving molded charges containing a pre-sensitized metal primer (No. 34) as the only noncombustible constituent. This round is illustrated in Figure 5. Limited firings have been conducted to date.

Work is in progress on the development of a percussion sensitive nonmetallic primer which will result in a completely combustible 7.62 mm round. A frangible primer, consisting of a polystyrene cup and anvil and a styphnate mix, has been made. The outer dimensions of the cup duplicate those of the standard metal cup. Firings have been

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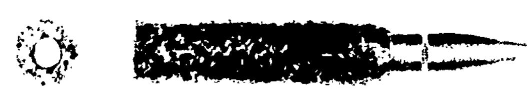

Figure 5. IMR 4895 Molded Charge with Conventional Primer

conducted with the Springfield type test action, using molded charges assembled with this primer. Small quantities of primer cup and anvil residue were found in the chamber and barrel, indicating the need for a combustible rather than frangible primer. The use of a nitrocellulose primer cup and anvil is being investigated.

A parallel approach has been started on the development of a 7.62 mm molded integral charge, using ball propellant as the granular constituent. Molded samples (in 7.62 mm configuration) consisting of various compositions and particle sizes of the granular constituents will be evaluated in the near future.

Any small arms combustible round, whether caseless or combustible cased, requires a film coating for protection against environmental conditions, heated chambers, etc. Tests are in progress on various film coatings.

The data obtained in the investigations described in this section are limited and are not included in this report. They will, however, be described in detail in the next report which will be issued upon completion of the development of a satisfactory combustible round and its companion test action.

CONCLUSIONS

1. A molded, integral propellant charge has been developed which, when used in conjunction with a metal case stub in a modified 7.62 mm test action, yielded performance meeting the ballistic requirements for the M59 cartridge.

2. The molded charge consisted of IMR 4895 granular propellant molded in a configuration similar to the 7.62 mm brass case, using nitrocellulose (pyroxylin) dissolved in ether-alcohol as the binder.

3. The ballistics of molded charges prepared with this binder vary with the relative quickness of the constituent propellant grains; thus offering means of burning rate control through selection of a suitable granular propellant.

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